CALCIUM AND IRON IN PLANT TISSUE

by

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B. S., American University of Beirut-Lebanon, 1957

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Chemistry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1961

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INTRODUCTION

There are considerable variations in mineral contents between species of plants and within the various parts of the same plant. Richardson (17) pointed out that the relative amount of various elements in plants apparently depend on a number of variables, such as species and genus of plant, the soil, the season, the rain fall, the state of cultivation etc., to such an extent that it is doubtful whether or not any sort of rule governing these proportions can ever be formulated.

Most of the environmental factors of the plants have been studied by many workers: Schrader and Haut (19) studied the effect of soil moisture on increasing the number of berries that developed, and where increasing soil moisture by irrigation under the hot dry conditions increased yield by increased number of berries and increased size of berries. Whittenberger (23) studied the pH of soil and he found that sunflower and rye grown on soil at high concentration of hydrogen ions favored accumulation of silicon in stems rather than in leaves. Roberts and Kenworthy (18) observed the effect on nutrient elements by changing the root temperature during vegatative period of development. They found that on the basis of dry-weight accumulation, maximum growth of all aerial parts of the plant during the vegetative phase of development occurred at root temperatures of 65 and 75 degrees F., regardless of nutrient solution concentration, and there was a significant increase in potassium in the leaves as root temperatures were increased, but very little effect on the composition of the plant for other nutrient-elements.

The effect of sunlight on silica deposition in sorghum was studied by Ponnaiya (16). He found that lack of direct sunlight only delays formation of silica deposits and that under normal sunlight, the deposits appear to be fully formed on the day of leaf emergence and further exposure to sunlight shows no further visible increase. Lanning and Linko (12) have found that silica content of leaves actually increases steadily over the growing season. Laiseca (8) has shown that the silica content of ash of beech leaves increases continuously from 1.2 percent in May to 24.4 percent silica by weight in November.

Cooper (5) found that plants having their rapid growth period early in the season are relatively low in calcium while the plants with a rapid growth period late in the season are relatively high in calcium. Bennett (4) observed that the iron content of leaves varies with species, leaf age, and soil conditions. He found that iron content increases rapidly during growth of leaves, then slowly after full size is reached, until the end of the season. Schrenk (21) found that the average calcium and iron content of Kansas wheat grain varies with location. That deposition is greater in tropical plants than in those of the temperate zone was observed by Latshaw and Miller (13).

Different species of plants were also studied. Miller (13) observed that members of the grass family have small amounts of calcium when compared with legumes, lettuce, cabbage and tobacco which are high. Different aerial parts of the same plant were studied by many workers. The nature and distribution of silica in strawberry plants was observed by Lanning (9). He found that the silica content of a strawberry plant is influenced by the soil in which it grows, and the silica content of leaves, stems, sheaths and crowns increased with age. Lineberry and Burkhart (14) observed the composition of soluble minerals in aerial parts of Klondike strawberry plants. They found that in the Klondike variety the concentration of soluble potassium and calcium in both leaves and fruit of plants that received complete nutrient solution were much higher than in the Blakemore variety. Major mineral elements of Kansas wheat were studied by Schrenk (20). He found that calcium is one of the major mineral elements of

Kansas wheat grain and that iron is one of the minor ones. Lanning, Ponnaiya and Crumpton (10) found that younger leaves of sorghum plants had much less silica deposition in the blade than in older leaves of sorghum plants.

Elvehjem and Hart (6) reported that many plants selectively absorb the strong ions or the elements with relatively high standard electrode potentials. Kwong and Boynton (7) found that time of sampling, leaf age and leaf fractions were factors influencing the concentrations of nutrient elements in strawberry leaves. Ballinger and Mason (2) pointed out that the concentration of nitrogen, phosphorus, potassium, calcium or magnesium in the plants increased with increases in concentration of the respective elements in the nutrient solution.

Studies on the relation between silica in wheat plants and resistance to Hessian fly attack has been observed by Miller, Robinson, Johnson, Jones, and Ponnaiya (15). Ponnaiya (16) pointed out that silica was deposited in most of the plant parts, the maximum quantity of the two distinct shaped particles of silica occurring in the leaf sheath. He found dumb-bell shaped units and irregular shaped units. Silica and calcium in black raspberries were studied by Lanning (11). He found that a large part of silica was deposited in the leaves and outer bark, and considerable calcium was deposited in the veins of leaves of black raspberries. Calcium in corn plant was studied by Latshaw and Miller (13). He obtained 58 percent in the leaves, 18 percent in the stems and 20 percent in the roots. Ash, silica, calcium and iron contents of strawberry and sorghum plants were studied by the author, and the results are presented here under.

PURPOSE

The purpose of this study was to determine and compare the ash, silica, calcium and iron contents in the various parts of strawberry and sorghum plants. In the case of sorghum the difference in the above mineral contents were determined for eight different experimental varieties. This gave a measure of the variations possible between varieties of the same species of plant. It also gave the variations in mineral content between the parts of the sorghum plants.

In the case of strawberries it gave the same type of information plus a comparison of iron and calcium contents of diseased and normal plants.

EXPERIMENTAL

Materials

The varieties of cultivated strawberry (Fragaria ananasse Bailey) plants studied were Dixieland, Surecrop, Armore and Blakemore. They were grown at the Horticultural farm of Kansas State University. Content of iron and calcium in roots, crowns, petioles, leaves without edges, and serrated edges of the leaves were determined separately.

Dixieland and Blakemore strawberry plants from Mound Valley (southeast Kansas) were also studied. These plants were suffering from a root rot complex. The organisms isolated were Rhizoctonia sp. and Verticillium albo-atrum. Iron and calcium contents were determined in roots, crowns, petioles, sheaths, leaves without edges and serrated edges of the leaves.

Silica, iron and calcium in roots, crowns, petioles, leaves without edges and serrated edges of the leaves of the Fragaria Virginiana strawberry were studied. The plants used were wild ones from Lewistown, Penn. (July, 1960).

Iron, calcium and silica were determined in leaves, roots and sheaths of three weeks old sorghum plants. They were grown in the summer of 1960, at the

Agronomy Farm north of Kansas State University and collected in July. The soil was non-calcareous and the pH was 5.2 (12).

The plants were not sprayed with lime containing materials.

Methods

The plants were seperated into parts to be tested, washed thoroughly with distilled water and dried in an oven at 110 degrees C. Known quantities of samples were ashed at 600 degrees C. and weighed. The ash was then treated with dilute hydrochloric acid. The excess acid was evaporated just to dryness, distilled water was added and heated for 15-20 minutes. Silica was separated from the solution by filtration, the residue was washed and the washings added to filtrate and made up to volume.

The silica was determined by using classical gravimetric techniques (12). The residue which was filtered out was ignited at about 600 degrees C., and silica content was determined by difference of weights before and after treatment with hydrofluoric acid.

Analysis of iron was made by the official standard A. O. A. C. titrimetric method using titanium trichloride as the titrant (1). Standard iron solution was prepared to measure number of grams of iron needed to neutralize one ml. of titanium trichloride. Sufficient potassium permanganate (1 + 1000) was used to oxidize ferrous to ferric iron and then five mls. of 10 percent ammonium thiocyanate as an indicator was added to 20 ml. aliquots of known and unknown ferric solutions, and then titrated with titanium trichloride. Change of red-blood color to colorless is the end point.

The filtrate which removed from the determination of iron was used for analysis of calcium. Calcium determination was carried out on a Beckman DU quartz Spectrophotometer equipped with a Model 9200 flame photometer attachment and photomultiplier unit. A Beckman spectral energy recording attachment permitted recording of spectra on a Model 5-72150 Sargent recorder. Calcium analysis had also been done by Kwong and Boynton (7) on flame photometer using Beckman Model B Spectrophotometer with photomultiplier and hydrogen flame.

The following instrumental conditions were used on the flame Spectrophotometer:

Acetylene pressure at 4 p.s.i.

Oxygen pressure at 12 p.s.i.

Slit width between .01 mm. to .015 mm.

Recorder range 25 mv.

Wavelength at 422.7 mu.

Scanning time 30.

Standard calcium solutions were prepared: 20 ppm., 40 ppm., 60 ppm., 80 ppm., and 100 ppm. The peak heights were found both for known and unknown calcium solutions at 422.7 mu. line on the Sargent recorder. Reading scale versus concentration of calcium in ppm. was drawn, and unknown calcium content of solutions were found by interpolation.

The percent ages of silica, iron and calcium were determined on moisture-free basis.

RESULTS

*Tables 1, 2, 3, 4, and 5 show that iron and calcium like silica were also present in all parts of the strawberry and sorghum plants, and there were also

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*The tables are in the Appendix.

considerable variations in iron and calcium content. Richardson (17) stated that of all elements found in plants, silicon showed the greatest variation between plant parts, plants, and species of plants. Silicon in strawberry and sorghum plants showed a greater variation than iron and calcium.

In strawberry plants (Table 1) petioles and serrated edges of the leaves had higher percent of ash than other parts of the plants. The crown had the least percent of ash. In Mound Valley strawberries (Table 2), the sheath had a higher ash content than other parts of the plants, roots had the least ash content. Serrated edges of the leaves of Fragaria Virginiana (Table 3) strawberries were higher in ash content than other parts of the plants, petioles had the least ash content.

The silica content in serrated edges of the leaves of strawberries studied were always higher than in other parts of the plant (Table 3), this is in agreement with the results of Lanning (9, 11).

The variations of iron content within the species of strawberry plants studied were not very great, but there were some differences in the different parts of the plant. Strawberries studied had similar calcium contents within the species of the plants, and different parts of the plants.

In Table 1, the iron content in the roots of Blakemore strawberry plants was lower than the iron in the roots of other strawberry plants. Calcium percent was higher in the roots of Blakemore plant than in the roots of other strawberry plants. Iron and calcium contents in Surecrop strawberries were higher than iron and calcium in the crowns of Blakemore, Dixieland or Armore strawberries. Petioles of Armore strawberry had higher iron content than petioles of the other strawberry plants mentioned above. The calcium content in Blakemore petioles was higher than the calcium content in the petioles of the other strawberries. Iron content in serrated edges of the leaves of these plants studied were about the same. Percent calcium was higher in serrated edges of Surecrop leaves than in the serrated edges of other strawberry leaves. Leaves without edges of Armore plants had higher iron content than leaves without edges of the plants mentioned above. A higher percentage of calcium in leaves without edges was found in Surecrop than in leaves without edges of other strawberries.

The iron content in the petioles and the crowns of the strawberries studied (Tables 1, 2, and 3), was lower than that for the other parts of the plants. The highest content of iron was in the roots which was ten times higher than the iron content in the crowns (Table 3). The iron content in the serrated edges of the leaves was slightly higher than leaves without edges.

The lowest calcium content in Mound Valley strawberry plants (Table 2) was found in the roots. Calcium content in crowns of the same plant (Table 2) was abnormally high. The petioles of Fragaria Virginiana strawberries (Table 3) had a lesser amount of calcium than other parts of the plant.

In all strawberry plants studied (Tables 1, 2, and 3), higher calcium contents were found in the crowns than in roots, sheaths, petioles or leaves. The serrated edges of the leaves (Table 1) were higher in calcium than leaves without edges. Calcium content in serrated edges of the leaves of Mound Valley strawberries was lower than the calcium content in leaves without edges of the same plant (Table 2), which is opposite to the results found in table 1. The differences between these strawberries and those grown at the Horticulture Farm, are probably due to the diseased condition of the Mound Valley plants.

Cowell (13) found the calcium content of the outermost leaves of cabbage to be 20 to 30 times as great as that of the inner leaves. Ballinger and Mason (2) observed that the central leaflet of strawberry plants was higher in calcium than two lateral leaflets at the three higher nutrient solution concentrations.

They also found that in 0 and 1/5 level of Hoagland and Snyder's nutrient solutions the calcium content was higher in the crown than other parts of strawberries. At 1 and 5 level of Hoagland and Snyder's nutrient solutions the central leaflet was higher in calcium than in other parts of the plant. Lineberry and Burkhart (14) determined the soluble minerals like calcium in the leaf, blades, petioles, crowns and roots of strawberry plants and the results were as follows: leaf blades, 2325 ppm.; petioles, 550 ppm.; crown, 200 ppm. and roots, 400 ppm.

Sheaths of sorghum plants (Table 4) had a higher percent of ash than leaves or roots. The sheath had a higher silica content than the leaves, the roots had the highest silica content at this stage, which was nearly twice as much as leaves. Lanning and Linko (12), also found that the silica content of sorghum roots at 21 days was higher than the silica content of leaves and sheath. As the plants got older they found that the silica content became higher in sheaths than in roots and leaves.

Table 5 shows that the iron content of sorghum roots was higher than in leaves and sheath which had nearly the same iron contents.

The calcium content of sorghum sheath was two and a half times that of the leaves and six times that of the roots (Table 5). The percentage of calcium in sorghum plants was reviewed by Beeson (3). They were as follows: sorghum, aboveground portions, cut before heads appeared grown in Oklahoma 0.36 percent (moisture-free basis); sorghum, green stalk, grown in Texas, 0.22 percent (moisture-free basis); sorghum, mature stalk, grown in Oklahoma, 0.081 percent (moisture-free basis). The average calcium content above the ground of sorghum plants studied was 0.31 percent (moisture-free basis), which is in agreement with the results reviewed by Beeson (3), which is 0.36 percent.

Considerable variation in ash, silica, iron and calcium contents were observed for any particular part of the eight experimental varieties of sorghum plants studied. For example, ash content of roots varied from 8.10 to 10.78 percent (Table 4). Similar variations occured in the ash content of sheath and leaves. Silica content of roots varied from 4.37 to 5.72 percent. Table 5 shows that iron and calcium content of roots varied from 0.073 to 0.125 percent and from 0.067 to 0.098 percent respectively. In sheath, iron and calcium varied from 0.017 to 0.040 percent and from 0.30 to 0.57 percent respectively. Similar variations occurred in iron and calcium contents of leaves.

By comparing the silicon, calcium and iron contents in the strawberry and sorghum plants studied the following results were noted: The average calcium content in strawberry plants studied was higher than the calcium content in sorghum plants. The average iron content in strawberry and sorghum plants was found to be lower than the average content of silica or calcium. Cooper (5) observed that the low value for iron in the plants is not due to deficiency of iron in the soil, but it is not absorbed by the plants. Calcium percentage in the Fragaria Virginiana strawberry was higher than silica content. The percentage of silica was higher in sorghum plants than the percentage calcium.

DISCUSSION

Due to environmental factors and types of plants the amount of calcium, iron and silica in the strawberry and sorghum plants varies greatly, as was observed also in plants by many other workers. In spite of variations there were some consistent results, such as the roots of different species of strawberry and sorghum plants had a higher iron content than the aerial parts of the plants. Crowns of strawberries studied had higher calcium content than the other parts of the plant. Silica in serrated edges of the strawberry leaves studied was higher than in the other parts of the plant. Roots of Mound Valley strawberries had the least amount of ash and calcium and highest amount of iron of all the parts of the plants (Table 2).

Schrenk (20) observed that calcium is one of the major mineral elements of Kansas wheat grain and that iron is one of the minor ones. This is in agreement with the iron and calcium contents in the strawberry and sorghum plants studied. Schrenk (21) also investigated the average iron and calcium content of wheat grass in 1945, 1946, 1947, 1948, and they were as follows: iron, 0.028 percent and calcium, 0.36 percent. These figures are quite comparable with the iron and calcium content of sorghum plants (Table 5). As we see in both cases calcium content was higher than iron content in those plants. Cooper (5) pointed out that there is a relation between the order of ion absorption by many organisms and the potential series. The more active ions are absorbed in greater quantities than the weaker ones, and he found that the metallic elements are in the same order as their standard electrode potentials. He also observed that there is a relation between the position of ions in the electromotive series and their activity in the soil colloidal complex is during the absorption of ions by plants.

Variations of calcium and silica had been investigated by Richardson (17), he observed that prunus had low silicon content and high calcium, whereas the grasses and the scouring rush store up large quantitives of silicon and are low in calcium. The strawberry plants studied had a high calcium content and a low silica content.

Strawberries are not only silica accumulator plants, which was observed by Lanning (9), but also are calcium accumulators.

Differences of iron and calcium in Mound Valley strawberry, Fragaria Virginiana strawberry and strawberries grown at the Horticulture farm of Kansas

State University might be due to the diseased condition of the plants. For instance, the roots of the diseased Mound Valley strawberry plants (root rot) had an abnormally low calcium content. The leaves without edges of these plants had an abnormally higher calcium content than the serrated edges of the leaves. Lanning (9) also observed a relationship between root rot and silica deposition in strawberry plants, and he found abnormally high silica content in the part of the leaf without serrated edges, and low silica content in the serrated edges of the same plant.

Sorghum plants were found to be silica accumulators as had been previously reported. The iron content of sorghum plants was considerably higher than that of strawberries and high for plants in general. The variation of silica content in sorghum and strawberry (plants and plant parts) was greater than for iron and calcium. This is in agreement with Richardson (17) observation about silica.

SUMMARY

1. Strawberry plants grown at the Horticultural farm of Kansas State University were collected in Spring, 1960. Iron and calcium contents were determined for roots, petioles, crowns, leaves without edges, and serrated edges of the leaves of 4 different species of strawberries: Dixieland, Surecrop, Armore and Blakemore plants.

   Crowns had a lower percent of ash and a higher percent of calcium than other plant parts. Roots had a higher iron content than other plant parts. Petioles and crowns had the lowest iron content.
2. Diseased strawberry plants were obtained from Mound Valley experiment station in Southeast Kansas. Iron and calcium content of petioles, crowns, sheath, root, serrated edges of the leaves and leaves without edges of Dix-

ieland and Blakemore plants were studied.

Ash and calcium were lower in roots than in other parts of the plants. Roots had highest iron content of the plant parts. The leaves without edges of these plants had an abnormally higher calcium content than the serrated edges of the leaves. The roots of the diseased plants (root rot) had an abnormally low calcium content.

3. Fragaria Virginiana strawberry plants were grown at Lewistown, Penn. and collected July, 1960. Silica, iron and calcium in root, crown, petioles, serrated edges of leaves and leaves without edges were studied. Roots had the higher iron and calcium content of the plant parts. Highest content of of ash and silica was found in the serrated edges of the leaves.
4. Three week old sorghum plants from the Agronomy farm north of the campus, were tested for silica, calcium and iron contents. A higher content of ash and calcium was found in sheath than in roots and leaves. Roots had the highest percent of iron and silica.
5. Roots in all the plants studied always had the highest percentage of iron of the plant parts. Silica in serrated edges of the leaves of strawberry plants studied was higher than the other plant parts.
6. The average silica content in strawberries studied was lower than the calcium content. The average silica content in sorghum plants was higher than calcium. The average iron content in both plants was much less than the average silica and calcium contents.
7. Considerable variations in ash, silica, iron and calcium contents were observed for any particular part of the eight experimental varieties of sorghum plants studied.

ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to Dr. Francis C. Lanning of the Department of Chemistry, Kansas State University, his major professor, who through suggestion and guidance made this investigation possible.

The investigation was supported by National Science foundation grant No. NSFG 7101.

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APPENDIX

Table 1. - Ash, Iron and Calcium in strawberry plants grown at the Horticulture Farm of Kansas State University.

Variety	Roots			Crowns			Petioles			Serrated edges of leaves			Leaves without serrated edges		
	Ash	Iron	Calcium	Ash	Iron	Calcium	Ash	Iron	Calcium	Ash	Iron	Calcium	Ash	Iron	Calcium
	Percent[a]			Percent[a]			Percent[a]			Percent[a]			Percent[a]		
Dixieland	6.39	0.055	0.95	5.94	0.007	1.87	10.21	0.007	0.73	9.65	0.024	0.95	8.49	0.020	0.63
Surecrop	6.48	0.051	0.88	7.46	0.023	2.33	10.80	0.007	0.74	10.23	0.016	1.12	9.55	0.014	0.82
Armore	7.59	0.048	1.00	5.32	0.007	1.22	10.32	0.010	0.74	9.09	0.021	0.81	8.76	0.025	0.65
Blakemore	7.41	0.030	1.04	5.61	0.006	1.21	10.77	0.003	0.82	10.38	0.017	0.98	9.60	0.015	0.67

a. Moisture-free basis

Table 2. - Ash, iron and calcium in strawberry plants grown in Mound Valley (southeast of Kansas).

Plant part	Dixieland			Blakemore		
	Ash	Iron	Calcium	Ash	Iron	Calcium
	Percent[a]			Percent[a]		
Edges of leaves	7.37	0.032	0.89	6.91	0.021	0.78
Leaves without edges	7.32	0.025	1.30	7.14	0.016	1.21
Roots	3.63	0.15	.54	3.52	0.050	0.60
Sheath	10.87	0.042	1.98	9.94	0.042	1.48
Crown	8.33	0.031	2.30	8.44	0.012	2.40
Petioles	7.32	0.011	0.87	7.38	0.009	1.13

Variety: Dixieland, Blakemore.

a. Moisture-free basis.

Table 3. - Ash, silica, iron and calcium in Fragaria Virginiana strawberry plants grown at Lewistown, Penn. (July, 1960).

Plant part	Variety: Fragaria Virginiana			
	Ash	Silica	Iron	Calcium
	Percent[a]			
Edges of leaves	7.41	1.38	0.052	1.12
Leaves without edges	7.12	0.21	0.042	1.43
Roots	7.22	0.57	0.13	1.83
Crown	6.41	0.078	0.014	1.36
Petioles	5.25	0.061	0.023	0.92

a. Moisture-free basis.

Table 4. - Silica and ash in sorghum plants grown at Agronomy farm north of the campus in summer, 1960[a].

Exp. Hybrid No.	Parentage	Roots		Sheath		Leaves	
		Ash	Silica	Ash	Silica	Ash	Silica
		Percent[b]		Percent[b]		Percent[b]	
57MH58	Redlan x 57M1201	9.85	4.37	15.44	3.44	10.38	3.00
57MH68	Wheatland x 53M58	10.78	4.93	15.90	3.33	10.12	2.83
57MH43	Martin x 56M4195	9.42	5.37	15.86	4.30	10.14	2.50
57MH36	Martin x 53M58	8.81	4.67	16.72	4.21	10.19	2.38
55MH11	Combine Kafir-60 x 56M4195	10.07	5.52	15.75	4.45	11.11	2.98
57MH48	Westland x 57M1201	9.65	5.40	15.77	3.77	10.67	2.98
57MH58	Redlan x 57M1201	8.10	4.47	17.89	4.74	10.50	2.63
56MH28	Combine Kafir-60 x 57M4084	10.45	4.58	18.17	3.49	10.81	2.87
57MH71	Martin x 57M4084	10.30	5.72	14.21	4.00	9.41	3.06
57MH71	Martin x 57M4084	10.29	5.45	16.37	4.49	10.64	4.10
	Average	9.77	5.05	16.21	4.02	10.40	2.93

a. Three week old sorghum plants. b. Moisture-free basis.

Table 5. - Iron and calcium in sorghum plants grown at Agronomy farm north of the campus, in summer, 1960[a].

Exp. Hybrid No.	Parentage	Roots		Sheath		Leaves	
		Iron	Calcium	Iron	Calcium	Iron	Calcium
		Percent[b]		Percent[b]		Percent[b]	
57MH58	Redlan x 57M1201	0.086	0.096	0.030	0.41	0.030	0.15
57MH68	Wheatland x 53M58	0.101	0.098	0.017	0.30	0.035	0.16
57MH43	Martin x 56M4195	0.110	0.067	0.023	0.57	0.033	0.13
57MH36	Martin x 53M58	0.078	0.082	0.021	0.47	0.025	0.31
55MH11	Combine Kafir-60 x 56M4195	0.090	0.070	0.019	0.45	0.033	0.30
57MH48	Westland x 57M1201	0.077	0.071	0.021	0.53	0.026	0.22
57MH58	Redlan x 57M1201	0.073	0.089	0.040	0.56	0.032	0.18
56MH28	Combine Kafir-60 x 57M4084	0.099	0.071	0.020	0.33	0.035	0.14
57MH71	Martin x 57M4084	0.125	0.074	0.025	0.47	0.018	0.16
57MH71	Martin x 57M4084	0.120	0.074	0.024	0.51	0.022	0.24
	Average	0.096	0.079	0.024	0.46	0.029	0.20

a. Three week old sorghum plants. b. Moisture-free basis.

CALCIUM AND IRON IN PLANT TISSUE

by

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B. S., American University of Beirut-Lebanon, 1957

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Chemistry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1961

There are considerable variations in mineral contents between species of plants and within the various parts of the same plant, as it was reported previously.

Ash, silica, calcium and iron contents were determined and compared in the various parts of strawberry and sorghum plants. In the case of sorghum the differences in the above mineral contents were determined for eight different experimental varieties. This gave a measure of the variations possible between varieties of the same species of plant. It also gave the variations in mineral content between the parts of the sorghum plants.

In the case of strawberries it gave the same type of information plus a comparison of iron and calcium contents of diseased and normal plants.

The plants were separated into parts to be tested, washed thoroughly with distilled water and dried in an oven at 110 degrees C. Known quantities of samples were ashed at 600 degrees C. and weighed. The ash was then treated with dilute hydrochloric acid. The excess acid was evaporated just to dryness, distilled water was added and heated for 15-20 minutes. Silica was separated from the solution by filtration. The residue was washed and the washings were added to filtrate which was made up to volume.

The silica which was filtered out was ignited at about 600 degrees C. and the content was determined by difference of weights before and after treatment with hydrofluoric acid.

Analysis of iron was made by the official standard A. O. A. C. titrimetric method using titanium trichloride as the titrant. Standard iron solution was prepared to measure number of grams of iron needed to neutralize one ml. of titanium trichloride.

The filtrate which was removed from the determination of iron was used for analysis of calcium. The calcium determination was carried out on a Beckman DU quartz Spectrophotometer equipped with a Model 9200 flame photometer attachment and photomultiplier unit. A Beckman spectral energy recording attachment permitted recording of spectra on a Model 5-72150 Sargent recorder.

The following standard calcium solutions were prepared: 20 ppm., 40 ppm., 60 ppm., 80 ppm., and 100 ppm. The peak heights were found both for known and unknown calcium solutions at the 422.7 mu. line on the Sargent recorder.

The percentages of silica, iron and calcium were determined on moisture-free basis.

Strawberry plants grown at the Horticultural farm of Kansas State University were collected in Spring, 1960. Iron and calcium contents were determined for roots, petioles, crowns, leaves without edges and serrated edges of the leaves of four different species of strawberries: Dixieland, Surecrop, Armore and Blakemore. Crowns had a lower percent of ash and a higher percent of calcium than other plant parts. Roots had a higher iron content than other plant parts. Petioles and crowns had the lowest iron content.

Diseased strawberry plants were obtained from Mound Valley Experiment Station in southeast Kansas. Iron and calcium content of petioles, crowns, sheaths, roots, serrated edges of the leaves and leaves without edges of Dixieland and Blakemore plants were studied. Ash and calcium were lower in roots than in other parts of the plants. Roots had highest iron content of the plant parts. The leaves without edges of these plants had an abnormally higher calcium content, than the serrated edges of the leaves. The roots of the diseased plants (root rot) had an abnormally low calcium content.

Fragaria Virginiana strawberry plants were grown at Lewistown, Penn. and collected July, 1960. Silica, iron and calcium in roots, crowns, petioles, serrated edges of leaves and leaves without edges were studied. Roots had the higher iron and calcium content of the plant parts. Highest content of ash and silica was found in the serrated edges of the leaves.

Three week old sorghum plants from the Agronomy farm were tested for ash, silica, calcium and iron contents. A higher content of ash and calcium was found in sheath than in roots and leaves. Roots had the highest percent of iron and silica.

Roots in all the plants studied always had the highest percentage of iron of the plant parts. Silica in serrated edges of strawberries studied was higher than the other strawberry plant parts.

Considerable variations in ash, silica, iron and calcium contents were observed for any particular part of the eight experimental varieties of sorghum plants studied.